Water Requirements of Young Blueberry Plants Irrigated by Sprinklers, Microsprays and Drip

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Keywords: *Vaccinium corymbosum*, evapotranspiration, irrigation, plant establishment, soil water content

Abstract

A study was done to determine the effects of irrigation method on water use by young northern highbush blueberry (*Vaccinium corymbosum* L. 'Elliott'). Plants were irrigated by overhead sprinkler, microspray, or drip at 50, 100, and 150% of the estimated crop evapotranspiration (ET_c) requirement. Irrigation was applied twice a week by sprinklers and three times per week by microsprays and drip. During the first two years after planting, plants irrigated by drip required only half the water for maximum shoot production as those irrigated by sprinklers or microsprays, using 203 mm (Jul.-Sept.) the first year and 376 mm (Apr.-Sept.) the following year. Overall, shoot dry weight was highest when plants were irrigated at 100% ET_c by drip or at 150% ET_c by microsprays. The benefit of these two treatments was likely due to higher soil water content and/or higher irrigation frequency, which probably enhanced plant water status over the other treatments. Based on plant responses to water applications, additional water (>150% ET_c) may further improve growth with microsprays but does not appear liable to improve it with sprinklers and drip. In fact, irrigation at 150% ET_c saturated the soil and significantly reduced shoot dry weight with drip. Further study is underway to determine how these irrigation methods will affect production and water use in mature plants.

INTRODUCTION

Most commercial highbush blueberry fields in the U.S. are irrigated by overhead sprinklers or drip (Strik and Yarborough, 2005). Sprinkler systems are relatively simple to install and maintain, but apply a portion of the water between rows where it is unavailable to the crop. Drip systems, by comparison, are somewhat more expensive to install and more difficult to maintain but offer superior water control and distribution uniformity. Water is usually applied one to two times per week as needed with sprinklers and every one to three days with drip.

A few growers are also using microsprays on blueberry. Although microsprays are not commonly used in blueberry, Holzapfel et al. (2004) found in Chile that production and water use efficiency were higher with microsprays than with drip. Microspray irrigation offers advantages similar to drip but applies the water to the soil surface by a small spray. Because microsprays wet more soil volume than drip, plants tend to produce a larger root system, which may provide an advantage in a shallow, densely-rooted crop such as blueberry (Patten et al., 1988).

The objective of the present study was to compare the water requirements for growing blueberry with overhead sprinklers, microsprays, and drip, and determine which method produces the most growth after planting. We hypothesized that plants would require less water and establish better when irrigated with drip or microsprays than with sprinklers as a result of more frequent and better controlled water applications.

MATERIALS AND METHODS

The planting was established at the Oregon State University Lewis-Brown Horticultural Research Farm, Corvallis, Oregon, USA (44°38′ N, 123°11′ W) in April 2004. Climate in the region is mild with average maximum temperatures ranging from 7.4-26.4°C and average minimum temperatures ranging from 0.4-10.3°C. Average annual precipitation is 1715 mm, but only 61 mm falls on average during summer (June-August). Soil at the site is a Malabon silty clay loam adjusted to a pH of 5.5. The plants were grown on mulched raised beds and spaced 0.76 m apart within rows and 3.05 m apart between rows. Normal cultural practices for mulching, fertilizing, and pruning were followed (Strik et al., 1993). Fruit buds were removed by pruning the first 2 years after planting to prevent fruiting and maximize vegetative growth (Strik and Buller, 2005).

Plants were established with hand-set sprinklers before irrigation treatments were initiated in July 2004. Nine treatments were arranged at the site in a strip-plot design with three irrigation methods (overhead sprinkler, microspray, and drip) and three irrigation levels (50, 100, and 150% of the estimated crop evapotranspiration requirements, ET_c). Each treatment plot consisted of three rows of eight plants and was replicated five times. Overhead sprinkler treatments were irrigated by four sprinklers per plot; a sprinkler was located on each corner of the plots and set to rotate in a 90^o wetting pattern. Drip treatments were irrigated by drip tubing, with in-line emitters spaced 0.30 m apart, placed along the row at a the base of the plants. Microspray treatments were irrigated with fan-jet emitters located between every other plant and suspended on a trellis wire 1.2 m above the plants. Although treatments will eventually be hand picked, each system was configured in such a way as not to interfere with mechanical harvesters. Irrigations were controlled by an automatic timer set weekly. Overhead sprinkler treatments were irrigated twice per week, as needed, while drip and microspray treatments were irrigated three times per week. The total amount of water applied to each treatment during the first two years of the study is shown in Table 1.

Crop evapotranspiration (ET_c) estimates were obtained for the site from the Pacific Northwest Cooperative Agricultural Weather Network (AgriMet) website (http://www.usbr.gov/pn/agrimet/) and were adjusted for plant size and irrigation system efficiency following procedures outlined in Holzapfel et al. (2004). Water applications were scheduled weekly and measured using flow meters installed in the irrigation manifold. Soil water content was measured monthly (June-August) in the top 0.30 m of the planting bed using a Trase time domain reflectometry (TDR) system with a 0.30-m waveguide; the waveguide was installed at two locations in the middle of the plot, approximately 0.15 m from two representative plants per treatment. One plant was randomly selected from each plot (outer rows only) and destructively harvested in November 2005. Shoots were oven-dried at 70^oC and weighed.

Data were analyzed by two-way analysis of variance (ANOVA) using ProcGLM (SAS Institute, Cary, N.C.) procedures. The main treatment factors were method and level of irrigation. Means with significant main effects were separated at 5% level of significance using Duncan's multiple range test.

RESULTS AND DISCUSSION

During the first year after planting, soil water content was significantly different among irrigation systems (Table 1). Essentially, soil water content was highest when plants were irrigated by drip and lowest when they were irrigated by sprinklers. Soil water content, however, did not differ significantly among irrigation levels until the second year after planting (Table 1). During the second year, soil water content among systems was again highest with drip but now was lowest with microsprays, and among irrigation levels, it was highest at 150% ET_c and lowest at 50% ET_c. Less soil water at 50% ET_c indicates that irrigation at this level was no longer completely rewetting the soil profile as it did the first season. By comparison, it appears that drip irrigation at 150% ET_c was over-wetting the soil profile, maintaining soil water content above field capacity (which was calculated as approximately 30%).

By the end of the second season, shoot dry weight was significantly affected by irrigation system ($P = 0.0013$) and irrigation level ($P = 0.0002$). The interaction between system and level was also significant ($P = 0.0052$). In general, drip irrigation produced the largest plants among the different irrigation methods and had the highest shoot weight when plants were irrigated at 100% ET_c (Fig. 1). Drip-irrigated plants required ≈580 mm of water over two seasons to reach their maximum shoot dry weight, while those irrigated by sprinkler or microspray required at least 1160 mm of water (Fig. 2). Note that because irrigation levels were adjusted for irrigation system efficiency (defined as the ratio of the volume of irrigation water beneficially used by a crop in a specified area to the volume of irrigation water delivered to this area) in each treatment, at 100% ET_c, we applied 20-36% more water by microspray and 117-138% more water by sprinkler than by drip each year (Table 1). Any benefit of drip was likely due to higher soil water content in this treatment, which probably improved water status of the cultivar. We previously found that because 'Elliott' produces a dense canopy, less water reaches the roots during sprinkler irrigation (or rain) and thus exposes the plants to more water stress (Bryla and Strik, 2007). Since soil water content was lower with sprinklers and microsprays than drip (Table 1), it is likely that a similar situation occurred in the present study.

Shoot weight was also high when plants were irrigated at 150% ETc by microspray (Fig. 1). Clearly, plants irrigated by microsprays benefited from the additional water; however, no benefit occurred when plants were irrigated by sprinklers and drip. In fact, shoot dry weight was significantly less at 150% ET_c than at 100% ET_c with drip (Fig. 1), which, when combined with the saturated soil conditions in this treatment (see above), suggests that these plants were over-irrigated. Over-irrigation tends to reduce root development and function in many plants including blueberry (Davies and Wilcox, 1984). It is less clear why sprinkler irrigation at 150% ET_c provided no benefit. Soil water content was similar between sprinkler plots irrigated at 100 and 150% ET_c and was less than field capacity (Table 1). Since plants were grown on mulched raised beds, perhaps most the additional water ran off the bed once a particular wetness was reached. Further investigation of water movement with different irrigation methods in mulched soil is warranted.

CONCLUSION

This study demonstrated that drip irrigation produced more plant growth with much less water than sprinklers or microsprays during blueberry establishment. Generally, blueberry plants that establish more quickly have higher production once fruiting begins. Our next step, as the field matures, is to start cropping the plants and begin examining the effects of different irrigation methods and scheduling amounts on fruit production in blueberry. Crop growth, water use, yield, and fruit quality will be measured in the study for at least three more years.

ACKNOWLEDGEMENTS

Thanks to Hannah Rempel, Will Fummerton, and Rick Moes for technical assistance. Mention of trade or manufacturer names is made for information only and does not imply endorsement or exclusion by the USDA ARS.

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Tables

Table 1. Total amount of water applied and soil water content in 'Elliott' blueberry plots irrigated by overhead sprinkler, microspray, and drip at 50, 100, and 150% crop evapotranspiration (ET_c).

Treatment	Water applied (mm) 2004	Water applied (mm) 2005	Soil water content (cm^3/cm^3)[1] 2004[2]	Soil water content (cm^3/cm^3)[1] 2005[3]
Sprinkler				
50% ET_c	229	472	25.4	20.8
100% ET_c	457	919	24.8	25.4
150% ET_c	683	1384	24.5	25.7
Microspray				
50% ET_c	155	229	26.8	15.8
100% ET_c	315	475	28.9	20.7
150% ET_c	457	701	29.2	24.8
Drip				
50% ET_c	104	185	29.1	29.4
100% ET_c	203	376	29.2	30.4
150% ET_c	295	526	30.8	34.9

[1]Data are the average of three measurements collected once a month in June, July, and August.

[2]Two-way ANOVA revealed a significant effect of irrigation system ($P < 0.0001$), but no significant effect of irrigation level ($P = 0.1425$) or the system x level interaction ($P = 0.0682$). Mean separation (Duncan's multiple range test; $P < 0.05$): sprinkler < microspray < drip.

[3]Two-way ANOVA revealed significant effects of irrigation system ($P < 0.0001$) and level ($P < 0.0001$), but no significant effect of the system x level interaction ($P = 0.2709$). Mean separation (Duncan's multiple range test; $P < 0.05$): microspray < sprinkler < drip; 50% ET_c < 100% ET_c < 150% ET_c.

Figures

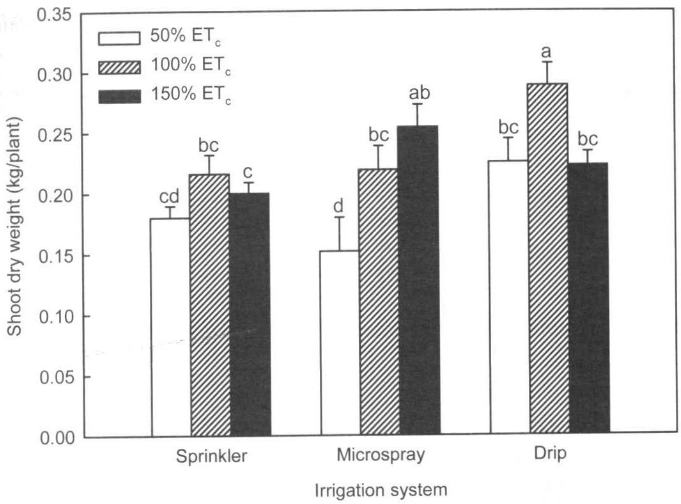

Fig. 1. Shoot dry weight of 'Elliott' blueberry irrigated by overhead sprinkler, microspray, and drip at 50, 100, and 150% crop evapotranspiration (ET_c). Each bar represents the mean of five replicates and error bars represent 1 SE of the mean. Different letters above the bars indicate significant differences among the means (Duncan's multiple range test; $P > 0.05$).

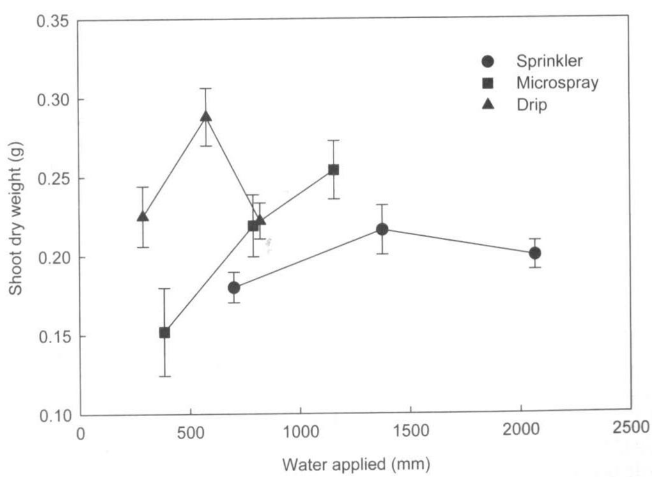

Fig. 2. Plant response to two seasons of applied water in 'Elliott' blueberry irrigated by overhead sprinkler, microspray, and drip. Each symbol represents the mean of five replicates and error bars represent 1 SE of the mean.